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Ejnar Hertzsprung, Chief Assistant, Observatory, Leiden, Holland; and

Georges Lecointe, Director of the Royal Observatory of Belgium, Uccle, Belgium,

were proposed by the Council as Associates of the Society.

Fifty-seven presents were announced as having been received since the last Meeting, including, amongst others:—

Five photographs of nebulæ, etc., taken with the 30-inch reflector of the Cordoba Observatory (enlarged transparencies), presented by Professor C. D. Perrine.

Note on Barnard's Observations of Nova Ophiuchi No. 2 (*Hind,* 1848) *and of Nova Persei No.* 2 (*Anderson,* 1901). By H. H. Turner, D.Sc., F.R.S., Savilian Professor.

1. In his interesting paper (*M.N.*, 81, 167) on Hind's Nova of 1848, Barnard suggests a period of 30 or 40 days for the fluctuations. A period of 27·3 days seems to fit the observations well. Taking the phases $27^{\mathrm{d}}\cdot3\ \theta^\circ/360^\circ$ from dates

$$2422096\cdot0 + 27\cdot3\,\mathrm{E}$$

as in the second column of the following table, and calculating the fourth column from the formula

$$\mathrm{C}_1 = 0\cdot18 \cos(\theta - 180^\circ) - 0\cdot04$$

(the second and third harmonics being small), we get a fair accordance, as shown by the column $\mathrm{O}-\mathrm{C}_1$. The first column gives the J.D. of observations in Central Standard time; for G.M.T. add 6^{h} or $0^{\mathrm{d}}\cdot25$. The column "Obs." is the difference of Barnard's observation from his mean value 12·35, expressed in units of 0·01 mag., and the same unit is of course used for C.

2. When the $\mathrm{O}-\mathrm{C}_1$ residuals were restored to time-sequence, a period of 54·6 days was suggested. The coefficient is 0·10, and in the column C_2 a small constant 0·02 is also included. The column $\mathrm{O}-\mathrm{C}_1-\mathrm{C}_2$ shows some reduction in the mean of the errors: and we can make a further reduction if we correct all the observations of 1919 by +0·03 and those of 1920 by −0·04 mag., there being a systematic difference between the two sets. But these two subsidiary hypotheses are more doubtful than the main assumption of 27·3 days.

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Table I.

Suggested Period of $27^{d}\cdot3$ *in Nova Ophiuchi No. 2.*

J.D.	Phase.	Obs.	C_1.	$O-C_1$.	C_2.	$O-C_1-C_2$.	Mean Values.
	d						
2481·5	3·3	−25	−17	− 8	+ 5	−13	−17
2509·4	3·9	−35	−15	−20	− 7	−13	−17
2127·4	4·1	− 5	−15	+10	− 6	+16	+19
2155·4	4·8	−15	−12	− 3	+ 4	− 7	− 4
2101·5	5·5	+ 5	−10	+15	+ 3	+12	+15
2129·4	6·1	− 5	− 7	+ 2	− 5	+ 7	+10
2458·5	7·6	+15	− 1	+16	− 4	+20	+16
2131·4	8·1	− 5	+ 2	− 7	− 2	− 5	− 2
2460·5	9·6	+15	+ 7	+ 8	− 1	+ 9	+ 5
2488·5	10·3	+15	+ 9	+ 6	− 1	+ 7	+ 3
2106·5	10·5	− 5	+10	−15	− 2	−13	−10
2080·5	11·8	+15	+13	+ 2	+ 2	0	+ 3
2162·4	11·8	+ 5	+13	− 8	− 3	− 5	− 2
2547·3	14·5	+35	+14	+21	− 5	+26	+22
2465·5	14·6	+25	+14	+11	+ 4	+ 7	+ 3
2138·4	15·1	+15	+13	+ 2	+ 5	− 3	0
2493·5	15·3	+ 5	+13	− 8	− 7	− 1	− 5
2085·6	16·9	+15	+10	+ 5	+ 7	− 2	+ 1
2141·4	18·1	− 5	+ 6	−11	+ 8	−19	−16
2551·4	18·6	− 5	+ 4	− 9	− 9	0	− 4
2087·5	18·8	− 5	+ 3	− 8	+ 8	−16	−13
2524·4	18·9	+15	+ 3	+12	+13	− 1	− 5
2115·5	19·5	−25	0	−25	−10	−15	−12
2470·5	19·6	+15	− 1	+16	+ 9	+ 7	+ 3
2472·5	21·6	+ 5	− 6	+11	+ 9	+ 2	− 2
2117·5	21·5	−25	− 6	−19	−11	− 8	− 5
2145·4	22·1	− 5	−10	+ 5	+ 8	− 3	0
2176·3	25·7	−25	−22	− 3	−10	+ 7	+10
		±390		±286		±244	±224

3. If this period is confirmed, it seems probable that the fluctuations have lengthened since the outburst in 1848, for the fluctuations which follow the appearance of a nova are usually of a few days' period only. But as between 1919 and 1920 no change in period is discernible from the present evidence.

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4. Barnard has, however, made a valuable series of observations of Nova Persei No. 2 (Anderson), given in *M.N.*, **80**, 712–715, which enables us to examine the behaviour of a nova nearer its outburst (16 to 20 years from discovery). A casual inspection suggested periods near 30 days and near 6 days, and it was determined to make a systematic examination, by Fourier analysis, of this series. The terminal dates are 2421207 and 2422405, differing by 1200 days, an interval which contains about 200 periods of 6 days. A direct attack on the problem would thus involve the examination of all divisors up to 200, an amount of work which is to be evaded if possible. The method of evasion corresponds to that of the use of a spectroscope of low resolving power in the first instance, to see whereabouts a bright line, if any, may be: and then the use of a higher-power instrument to give precision to the determination.

5. Resolving power corresponds to length of series, and we must thus break up the series of 1200 days into shorter lengths. A length of 200 days was adopted, since there are roughly three annual series of about this length, if we omit the few observations in 1916–17. To simplify the work as much as possible, each presumed cycle was divided into 4 parts only. In previous work of this kind a cycle has usually been divided into 12 parts, which gives a sensibly correct value for the coefficient. In using so small a number of parts as 4, we naturally diminish the available coefficient. But the diminution is slight, as a simple example will show. Suppose we have a series of 12 terms

$$0,\ +5,\ +F,\ +10,\ +F,\ +5,\quad 0,\ -5,\ -F,\ -10,\ -F,\ -5,$$

where F is written for $10 \sin 60° = 5\sqrt{3}$. By the usual 12-term analysis we should get a coefficient 10. If now we group the 12 terms in 4 sets of 3, beginning with the last, we get the 4 mean values

$$0,\quad 9{\cdot}1,\quad 0,\quad -9{\cdot}1,$$

which give a coefficient 9·1 instead of 10·0. The diminution is not serious enough to interfere with the main (exploring) purpose of the analysis.

6. In Table II. it will suffice to give the values of $R^2 = a^2 + b^2$ (where a and b are the coefficients of $\sin\theta$ and $\cos\theta$) for the three groups of 200 days. The first cycle of $33^{d}{\cdot}3$ (divisor 6) had for mean values of the 4 portions

$$13{\cdot}59,\quad 13{\cdot}80,\quad 14{\cdot}12,\quad 13{\cdot}61,$$

and the first harmonic is thus

$$-0{\cdot}265 \cos\theta + 0{\cdot}095 \sin\theta.$$

The value of R^2 is thus $(0{\cdot}265)^2 + (0{\cdot}095)^2 = {\cdot}079$, which is written as 79.

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TABLE II.

Intensities of Periodicities for Nova Persei No. 2, deduced from the Three Sets of Barnard's Observations.

Divisor.	Period.	1917–18.	1918–19.	1919–20.	Sums.	
					(1).	(2).
	d					
3	66·7	32	11	28	71	50
4	50·0	36	8	82	126	102
5	40·0	22	3	34	59	44
6	33·3	79	30	9	118	65
7	28·6	104	9	0	113	44
8	25·0	26	2	3	31	14
9	22·2	77	12	6	95	44
10	20·0	31	6	23	60	39
11	18·2	16	3	11	30	19
12	16·7	6	24	2	32	28
13	15·4	69	6	2	77	31
14	14·3	36	12	22	70	46
15	13·3	6	12	13	31	27
16	12·5	73	22	7	102	53
17	11·8	8	1	5	14	9
18	11·1	84	30	1	115	59
19	10·5	60	22	7	89	49
20	10·0	48	8	14	70	38
21	9·5	9	2	4	15	9
22	9·0	50	1	12	63	30
23	8·6	50	14	25	89	56
24	8·3	33	26	0	59	37
25	8·0	9	20	63	92	86
26	7·7	8	2	6	16	11
27	7·4	40	7	14	61	34
28	7·1	56	37	49	142	105
29	6·9	33	7	16	56	34
30	6·7	30	12	8	50	30
31	6·5	58	0	6	64	25
32	6·3	108	20	60	188	116
33	6·1	8	28	0	36	31
34	5·9	16	5	17	38	27
35	5·7	24	5	14	43	27
36	5·5	34	11	17	62	39
37	5·4	56	5	6	67	30
Mean	...	42	12	14	68	40

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7. A mere glance at Table II. suffices to show that the numbers of the third column are sensibly larger than those of the fourth and fifth: in other words, the results after 1918 March are sensibly different from those before. This cannot be attributed to the observer. It is true that the number of comparisons per night increases slightly along the series, being 3·5 in 1916–17, 6·2 in 1917–18, 7·0 in 1918–19, and 8·1 in 1919–20. This greater assiduity, and perhaps a little greater familiarity with the field of stars, might account for a *slightly* reduced mean deviation: but the change in mean of R^2 is serious, being 3 to 1, steadily over the long series of divisors. This sudden reduction in the fluctuations of the star seems noteworthy as a physical fact.

8. But it has also a special consequence for our exploring work. Were the three columns homogeneous, it would be natural to take their sum, as in the fifth column under head (1), as the periodogram. But the general principle of the periodogram method is to select terms in which R^2 is large compared with its mean value. It is clearly unsound to add together for this purpose three columns with such different mean values. It is preferable to divide the first by 3 before taking the sum, and this revised addition is given under heading (2) in the last column.

9. From either (1) or (2) we are led to reject the suggestion of a periodicity near 30 days. It is chiefly due to the 1917–18 observations, and is not supported by the later ones. But perhaps a reservation may be made. If there was a physical change in the star in 1918, as indicated by the considerable reduction in fluctuation, there may have been a periodicity near 30 days before 1918. For elucidating this point we require earlier observations.

10. Divisor 32 gives the most conspicuous suggestion in either column (1) or (2). Recurring to the coefficients of sin θ and cos θ, we get for the three determinations—

in 1917–18 . . $0·33 \cos(\theta - 304°)$
in 1918–19 . . $0·14 \cos(\theta - 4°)$
in 1919–20 . . $0·24 \cos(\theta - 140°)$.

If it is a real periodicity the phase should change uniformly; and since the intervals between consecutive sets are approximately equal (one year each), the mean of the first and third phases should agree with that of the middle. The difference 38° is not large, and we may accept this periodicity as possibly real. Since the phase increases 196° in two years, the period is longer than 6·25 days: we may put its length at 6·279 days, which is nearly 69/11 days. If we divide each cycle into 6 equal parts of length 69/66 days, the mean magnitudes for these parts are found to be—

	(1).	(2).	(3).	(4).	(5).	(6).
1916–18	13·62	13·43	14·04	13·78	14·02	13·56
1918–19	13·67	13·95	13·70	13·91	13·80	13·83
1919–20	13·11	13·02	13·26	13·40	13·53	13·11
Mean	13·47	13·47	13·67	13·70	13·78	13·50

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The second group is not very accordant, but we are already prepared for this. The maximum and minimum may be put in columns (1) and (4) respectively, and to this test the second line responds: but it is anomalous in intermediate columns.

11. Turning now to divisor 28, period near 7·1 days, the results for the three years are—

1917–18 . . $0·12 \cos(\theta - 111^\circ)$
1918–19 . . $0·10 \cos(\theta - 303^\circ)$
1919–20 . . $0·11 \cos(\theta - 215^\circ)$.

Now the mean of first and third phases is, as they stand, 163°, differing from 303° by 140°: but we may, of course, increase or diminish any phase by 360°. The phases would then be—

either 471° 303° 215°, period 7·100 days
or 111° 303° 575°, period 7·222 days.

We should normally expect to be able to choose the right alternative by inspection of the results for neighbouring divisors. Thus even in the value of R^2, if the true period is longer than 7·143 days (divisor 28), we should expect the results for divisor 27 to be larger than those of 20 in Table II. But the results for 27 and 29 are the same in column (2) and nearly the same in column (1). Even when we go back to the coefficients of $\sin\theta$ and $\cos\theta$, which ought to change sign at a periodicity, we get no help. This throws grave doubt on the reality of this term, doubt which is increased by the smallness of the coefficients.

12. With some diffidence I venture to ascribe this apparent periodicity to the effects of observing on regular days of the week. If we take the 7·100 days alternative and arrange 71 days in 10 sets of 7, we find the records all occurring in three boxes out of the 7, the other days being blank. When we proceed to the next set of 71 days, the occupied boxes change their position by one day, of course: so that we ultimately get material in every box. But that in one box is of very different date from that in another. Now the mean magnitude of Nova Persei is very different at different dates. Thus for 1917–18 December and January it is well over 14·00, while in 1919 October it is under 13·00. Hence we are liable to get a spurious periodicity from this lack of uniformity in date. We may collect the results as before—

	(1).	(2).	(3).	(4).	(5).	(6).	(7).
1916–18	14·22	13·55	14·00	13·25	13·74	13·53	13·65
1918–19	13·76	14·18	13·59	13·70	13·46	13·90	13·69
1919–20	13·40	13·40	12·93	13·25	13·14	13·02	13·58
Mean	13·79	13·71	13·51	13·40	13·45	13·48	13·64

But although the mean values show a distinct fluctuation, the variation from one group to the next is considerable, and almost certainly due to the cause above mentioned. A periodicity near

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7 days should be very clearly marked to be above suspicion of this kind.

13. The shorter periods attracted first attention, because there are undoubtedly considerable fluctuations within a few days. But unless the 69/11-day period is real, there does not seem much chance of any *permanent* short-period term. We may now turn to the longer periods, and we are at once struck by a period of about 400 days. If we take means for consecutive sets of 40 days each, counting from J.D. 2421200, and arrange them in ten boxes, we get the following results :—

TABLE III.

Long Period (400 *Days*) *in Nova Persei.*

(1).	(2).	(3).	(4).	(5).	(6).	(7).	(8).	(9).	(10).
14·03	13·17	13·55	...	...	...	12·96	13·50	13·66	14·25
14·25	14·08	...	...	...	13·47	13·82	13·51	13·39	14·10
14·12	14·12	...	...	...	13·16	12·97	13·29	13·19	13·43
13·75	13·32	...	...	13·40	12·99	13·36	13·59	13·30	13·06
14·04	13·67	13·55	...	13·40	13·21	13·28	13·47	13·38	13·71

(The last six results are from unpublished observations by Barnard.) There is a clear and rather sharp minimum, but unfortunately the maximum has not yet been fully observed owing to the period being so nearly one year. The harmonics of this periodicity are probably noticeable, and we may perhaps ascribe the large value of R^2 for divisor 4 (period 50 days) in Table II. to this cause.

14. The period of 400 days corresponds to divisor 3 for the whole available range of 1200 days. If we now analyse the whole series for long-period terms (taking means for 10 days to shorten the work), we get results as in Table IV. We can interpret them in terms of the long-period term and its harmonics alone on the assumption that the true period is rather longer than 400 days. Thus the fourth harmonic appears, not with divisor 12, or period

TABLE IV.

Possible Long-period Terms in Nova Persei.

Divisor.	Period.	R^2.	Divisor.	Period.	R^2.
	d			d	
3	400	180	12	100	7
4	300	4	13	92	9
5	240	33	14	86	36
6	200	117	15	80	2
7	171	8	16	75	6
8	150	11	17	71	6
9	133	38	18	67	18
10	120	1	19	63	3
11	109	50	20	60	20

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100 days, as we might expect, but with divisor 11, period 109 days. Hence the true period would seem to be longer than 400 days, though not much longer. Since R^2 is greater for divisor 6 than for divisor 5, the half period should be nearer 200 days than 240; *i.e.* less than 220 days. By similar inspection of successive harmonics we can thus assign as superior limits 440, 423, 460, 445, 414 days, etc. The guidance necessarily becomes weaker as we descend the scale: if we may trust that of the sixth harmonic the period must be <414 days.

15. After the paper had been sent in, some more observations were received from Barnard (and have now been incorporated in Table III.). For comparison with Table III. let us adopt a period of 420 days, which is about the longest likely to be consistent with Barnard's observations.

TABLE V.

Suggested Period of 420 *Days in Twelve Groups of* 35 *Days each, beginning with* 2421200.

(The unit is 0·01 mag., counted from 12·00. Suffixes show the number of nights of observation.)

(1).	(2).	(3).	(4).	(5).	(6).	(7).	(8).	(9).	(10).	(11).	(12).
203_5	117_3	184_2	97_1	...	...	...	96_5	150_6	166_{10}	201_5	222_5
228_3	...	...	...	...	...	171_7	192_6	136_8	155_3	215_9	202_5
211_2	...	...	...	93_1	106_9	104_9	137_5	133_7	163_3	147_4	...
...	...	...	140_6	98_9	131_8	152_5	167_4	109_3	...	...	...
212	117	184	134	97	118	138	139	135	163	197	212
189	173	153	132	117	113	119	135	155	176	191	195

16. Harmonic analysis of the mean curve shown just below the rule gives (in ordinary units)

$$13{\cdot}54 + 0{\cdot}42 \cos(\theta - 328^\circ) + 0{\cdot}10 \cos(2\theta - 315^\circ) + 0{\cdot}18 \cos(3\theta - 229^\circ);$$

or, reducing to standard form,

$$2{\cdot}94 \cos(\theta - 180^\circ) + 0{\cdot}70 \cos(2\theta - 19^\circ) + 1{\cdot}26 \cos(3\theta - 145^\circ).$$

The relatively large third harmonic makes it doubtful whether the long-period variable classification is relevant, but the phase of the second harmonic indicates Group I. The curve corresponding to the first formula is shown in the last line of Table V.

17. Using this last line to test the separate cycles for epoch, they give no clear indication of progression in phase, and we infer that Barnard's observations alone do not suffice to assign the period more closely than as 400–420 days. We may put his

max. at 2421813 ± 420 *n* to 400 *n*
min. at 2422023 ± 420 *n* to 400 *n*.

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18. The question now arises whether we can trace the term in earlier observations. Looking backwards, we have

(*a*) A series of observations by Dr. W. H. Steavenson in the autumn of 1915 (*B.A.A. Journal*, 1916 January). They extend over 77 days only, and do not show much change in mean value, though they show fluctuations of short period. They do not help much for the present purpose.

(*b*) C. R. D'Esterre gives some photographic observations in *M.N.*, **74**, 535. Let us try the suggested period of 420 days: beginning with $2421200 - 5 \times 420 = 2419100$, and arranging them in twelve portions of 35 days as in Table V., we get the mean result of Table VI.

TABLE VI.

D'Esterre's Observations in $420 = 12 \times 35$ *Days.*

(Unit 0·10 mag.)

(2).	(3).	(4).	(5).	(6).	(7).	(8).	(9).	(10)
...	...	...	...	124_1	...	...	118_1	...
...	...	123_1	...	124_2	...	122_8	119_3	118_4
127_2	124_3	126_2	120_1	120_2	125_5	127_9	130_2	...

19. There are no observations in portions (1), (11), and (12), which have accordingly been omitted from the table. There would appear to be a distinct maximum about the end of the second line, with which the line above accords, but not the line below. Several reasons may partly explain the discordance. Firstly, the star was fading, the mean magnitude being about 12·3, whereas Barnard's observations show that a year later it was about 13·3; secondly, there are undoubtedly fluctuations in brightness of short period which may cause accidental deviations; thirdly, we may not have adopted the right period.

20. The last point is the most important for us: we can see that there is another apparent maximum in the third line about portions (5) and (6). The interval between the two, however, cannot be greater than nine portions of 35 days = 315 days, which is not reconcilable with what we already know of the period. If the period has remained constant (which is of course an assumption), one or other of these apparent maxima must be spurious. Their approximate dates are 2419835 and 2420115. Combining the former with Barnard's 2421813, we get 1978 days $= 5 \times 396 = 4 \times 494$ days; combining the latter, we get 1698 days $= 4 \times 425$ days.

21. Going further back, we find observations by Nijland (in *A.N.*, 4303) from 2416681 to 2418037. The mean magnitude was then 10·5, and the observer comments on the smallness of any deviations from it. Carrying back the period of 420 days, we get for the twelve portions

(1).	(2).	(3).	(4).	(5).	(6).	(7).	(8).	(9).	(10).	(11).	(12).
57	63	56	58	59	56	41	64	53	60	66	59

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22. These figures give, in units of 0·01 mag., the excess over 10·00 mag. Harmonic analysis of them gives, in ordinary units,

$$10\cdot58 + 0\cdot04 \cos(\theta - 340^\circ) + 0\cdot03 \cos(2\theta - 195^\circ).$$

The phase of θ is not far from Barnard's 328°, but the coefficient 0·04 is only one-tenth of his coefficient 0·42. There may, however, be a sufficient reason for this discrepancy, without supposing any essential change in the 400-day variation. We have seen that the star was 3 mag. brighter when Nijland observed it in 1904–8 than it is now. If we may regard this difference as due to a quantity of added light which is independent of the 400-day term we are studying, the fluctuation will naturally form a smaller percentage of the whole. Thus let the light at minimum now be called L: then at maximum, which is 0·84 mag. brighter, the light is 2·2 L (since log $2\cdot2 = 0\cdot4 \times 0\cdot84$). Hence the fluctuation represents an addition of 1·2 L. Now in Nijland's time the star was about 3 mag. brighter, and thus the light at minimum was 16 L: the addition of the same 1·2 L would only increase it to 17·2 L, representing a change in magnitude of $(1\cdot236 - 1\cdot204)/0\cdot4 = 0\cdot08$, which is just what we have found. If then we can trust so small a coefficient and the phase accompanying it, a period of 420 days will carry back to Nijland's time. But of course it is not the only alternative. The maximum may be put at 2417200, which differs from Barnard's 2421813 by 4613 days $= 11 \times 419 = 12 \times 384$ days.

23. In view of the great diminution of the coefficient (whether the reason be rightly assigned or no), it seems unprofitable to consider previous observations back to the time of the outburst in 1901. But before that the star was of about the same brightness as Barnard now finds it, and in *H.C.*, 66, Professor E. C. Pickering collected a number of observations of it derived from early photographs, as shown in Table VII.

TABLE VII.

Observations of Nova Persei before 1901 (*H.C.*, 66).

Date.		J.D. 2410000+	Obsd. Mag.	Phase of 396 Days.	Barnard's Curve.	O – C.
				d		
1890	Oct. 26	1667	12·95	367	13·63	–0·7
	Dec. 2	1704	13·37	8	14·00	–0·6
1891	Jan. 20	1753	<13·7	57	13·80	–0·1+
	Mar. 11	1803	<13·4	107	13·28	+0·1+
	Dec. 10	2079	<13·7	383	13·77	–0·1+
1893	Jan. 25	2489	14·06	1	13·91	+0·1
1894	Oct. 11	3113	13·15	229	13·23	–0·1
1897	Oct. 17	4215	13·46	143	13·40	+0·1
1900	Mar. 7	5086	13·36	222	13·29	+0·1

The first three columns are from *H.C.*, 66. The last three will be explained in a moment.

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24. It is risky to make inferences from such isolated observations, but we may perhaps conjecture that the variation was more regular before 1901 than after, being free from the short-period fluctuations which resulted from the outburst of 1901. If so, there appears to be a minimum near 2412489. Adopting it as the exact date of minimum, as the best we can do, and comparing with Barnard's 2422023, we get a difference of $9534 = 22 \times 433 = 23 \times 415 = 24 \times 397$.

25. The last of these, 397 days, is close to the value which suits D'Esterre's observations on the more probable of two suppositions, while 415 days does not agree with the alternative. Of course the whole supposition of a permanent periodicity is precarious. There seems, however, to be something to be said for it: if so, 396 days seems the best value of the period. The light curve must be nearly as in Table III. We can only obtain an approximate light curve, owing to the paucity of observations in portions (3), (4), and (5). The figures of Table III. give

$$13{\cdot}52 + 0{\cdot}28 \cos(\theta - 8^\circ) + 0{\cdot}08 \cos(2\theta - 31^\circ) + 0{\cdot}12 \cos(3\theta - 352^\circ).$$

26. If we go back to the original observations and arrange them in 12 groups of 33 days each, we get the numbers of Table VIII.

TABLE VIII.

Barnard's Observations in Period of $396 = 12 \times 33$ *Days.*

(Unit 0·01 mag. above 12·00.)

	(1).	(2).	(3).	(4).	(5).	(6).	(7).	(8).	(9).	(10).	(11).	(12).
	203_5	109_1	167_3	97_1	...	...	...	178_1	76_4	149_8	170_9	215_5
	224_5	218_2	...	...	...	...	...	163_5	188_7	138_5	142_6	211_7
	211_6	212_4	...	...	...	...	98_2	106_8	112_7	137_5	133_7	146_2
	156_5	...	...	...	...	152_2	129_{10}	90_8	151_4	159_7	184_1	100_5
O	199	188	167	97	(157)	152	124	117	137	147	153	176
C	202	190	144	128	143	150	130	120	131	144	151	176

We may either take the simple mean of the results, or the weighted mean. Since the deviations are of short period, the latter seems the more appropriate, but the other is nearly the same. Harmonic analysis gives

$$13{\cdot}51 + 0{\cdot}28 \cos(\theta - 4^\circ) + 0{\cdot}15 \cos(2\theta - 346^\circ) + 0{\cdot}13 \cos(3\theta - 51^\circ),$$

the corresponding curve being shown in the last line (C).

27. D'Esterre's observations, arranged in the corresponding groups, give in the mean (unit 0·01 mag. in excess of 10·00)

(1).	(2).	(3).	(4).	(5).	(6).	(7).	(8).	(9).	(12).
240_4	260_1	236_6	200_1	215_6	249_8	256_{10}	170_1	240_1	265_2

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If we supply values for the missing groups (10) and (11) by interpolation, and analyse, we get

$$12{\cdot}38 + 0{\cdot}18 \cos(\theta - 334^\circ) + 0{\cdot}14 \cos(2\theta - 305^\circ) + 0{\cdot}22 \cos(3\theta - 114^\circ).$$

28. Nijland's observations give sensibly zero for the coefficients, and thus contribute nothing to the evidence: but a possible reason for this has already been indicated. Perhaps the relations of the three sets of observations may be usefully indicated thus: let us arrange the groups according to the value of C in Table VIII., *i.e.* according to the magnitude as shown by Barnard's curve.

TABLE IX.

Group.	Barnard.	D'Esterre.	Nijland.
(1)	202	240	59
(2)	190	260	60
(12)	176	265	46
(11)	151	...	64
(6)	150	249	64
(10)	144	...	60
(3)	144	236	67
(5)	143	215	52
(9)	131	240	53
(7)	130	256	60
(4)	128	200	...
(8)	120	170	53

29. The correlation between Barnard and D'Esterre is 0·7 : that between Barnard and Nijland is reduced to zero by the single discordant 46 for group (12) in Nijland due to two observations giving the star exceptionally bright. There are undoubted fluctuations of short period which may easily account for this, but they leave the whole question of *permanent* variability in 396 days uncertain.

30. The early observations of *H.C.*, 66, are compared with Barnard's curve in the last three columns of Table VII. The earliest two do not fit, but the others are in fair accord. It must, of course, be remembered that we selected the period to fit the observation of 1893 January 25, but there are six others which might easily have shown discrepancies and do not. It may be added that the observations of 1890 are described in *H.C.*, 66, as "somewhat uncertain."

Summary.

1. Barnard's observations of Nova Ophiuchi No. 2 (Hind, 1848) from J.D. 2422080 to 2422551 fit well with a period of 27·3 days. There is also possibly a periodicity of double this length.

2. His observations of Nova Persei No. 2 (Anderson, 1901) from 1916–20 have been analysed for periods from 400 days to 5 days. There is apparently a well-marked periodicity of something under 400 days (say 396 days), the harmonics of which are in good evidence. Beyond this there is nothing likely to be real except perhaps a fluctuation in 69/11 days. Another small fluctuation near 7 days is probably due to the interaction of the long-period term with the effect of regular weekly observing.

3. The long-period term of 396 days can be probably traced back to before the outburst of 1901, as shown by the observations in *H.C.*, 66. But *after* the outburst it was so much diluted by the flood of extra light that it is only doubtfully traceable until about 1914, when D'Esterre made some observations.

The Ultra-Violet Spectrum of Nova Aquilæ, 1918 *June* 10.

By the Rev. A. L. Cortie, S.J.

In my paper on "The Earlier Spectrum of Nova Aquilæ, 1918,"* the fiducial points for the measurements of wave-lengths were taken at the more refrangible edges of the bright bands at H_β, H_γ, and H_δ. These positions were in good agreement with the micrometer readings of a normal spectrum. The deduced wave-lengths of the dark absorption spectrum, and of the bright bands, were sufficiently accurate for the purpose of identification with the α Cygni spectrum. Thereby the main object of the paper was fulfilled.

In these earlier spectra of the nova the hydrogen series is double, the first series of lines being broad but well defined, while the second or more refrangible series is broad, fuzzy, and ill defined. In most cases, too, notably in H_β, H_γ, H_δ, the lines of the second series are composed of several thin bright lines. On account of the unequal displacement to the violet of these two series of broad lines, and also of the irrationality in the dispersion of a prismatic spectrum, in the more refrangible regions, overlapping of the two series of displaced lines takes place. Broad lines or narrow bands are accordingly formed which may also possibly contain coincident metallic lines, other than those due to hydrogen. The overlapping begins at H_μ of the first series, which forms a broad line with H_λ of the second series.

The purpose of the present paper is to separate the two series of lines in the ultra-violet, which was not successfully accomplished in my first paper. This was due to the inexactness in the selection of the fiducial points. Plates taken with a prismatic camera labour under the disadvantage, which is absent from photographs secured with slit spectroscopes, of the absence of a comparison spectrum.

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* *Monthly Notices*, 79, 123.